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SPECIFICATIONS FOR AN INTEGRATED WATER QUALITY DATA ACQUISITION SYSTEM

A. F. Mentink

Federal Water Pollution Control Administration
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A.T.Wicks

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Springfield VA 22151

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Basic Data Program
Water Quality Activities
Engineering & Field Operations

January 1966

(Sixth Edition)

INTRODUCTION

This is the Sixth Edition[1] of "Specifications for an Integrated Water Quality Data Acquisition System" and includes several improvements and slight variations from those issued previously:

a) Response for each parametric system has been adjusted to five minutes to attain 98% of a new steady state value. A fast response is desirable for obtaining cross sections where parametric (including temperature) gradients exist and time is minimal.

b) Active analyzer output signal levels require either of two combinations:

   1) 0-10 millivolt direct current and 0-1000 millivolt direct current, full scale.

   2) 0-50 millivolt direct current and 0-1000 millivolt direct current, full scale.

   Normalization of analyzer output signals to either (1) or (2) is desirable to provide flexibility in obtaining the output phases.

c) The chlorides parametric system is provided with either manual or automatic range change features on an optional basis.

d) The sample taker has been included as a separate parametric system. This capability is useful in applications where a sample must be drawn when particular conditions exist. Similar to other parametric systems, the sample taker parametric system is optional.

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[1] In order; the first version was completed and assembled by the writer in November 1962; the second was prepared for review in January 1963; the third version was sent out to bid in March 1963; the fourth edition was issued in August 1963; and the fifth edition was issued in May 1964.

As noted in previous issues, the range is a function of locality, so that Paragraphs X.01 can be adjusted for each installation within practical design limits.

It is evident that a selection of parametric systems or output phases is readily obtained.

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SPECIFICATIONS FOR AN INTEGRATED WATER QUALITY DATA ACQUISITION SYSTEM

SCOPE OF WORK

The contractor shall construct and furnish an automatic water quality data acquisition system and spare parts as specified below.

The water quality data acquisition system shall consist of eight parametric systems: pH, conductivity, dissolved chlorides, dissolved oxygen, oxidation reduction potential, solar radiation intensity, temperature and turbidity. Each parametric system shall consist of a primary sensor and an analyzer and, where specified, automatic temperature compensation. All parametric systems and multiple ranges, where specified, and a test signal shall terminate into either a 24-point multipoint strip-chart recorder, or, into a standard 8-channel paper tape, or, into both in which case the analog and digital devices would be completely independent of each other. With the exception of solar radiation intensity, all primary sensors shall be immersed in the water sample under test.

Since automatic sample taking requirements exist in isolated cases, a parametric sample taking system is included as a section. This assumes an active analyzer similar in construction to other parametric analyzers. However, mounting the sample taking analyzer in the rear of the recorder or analyzer cubicle or on a common power pack is acceptable.

The system is composed of four fundamental phases: the flow chamber, the analyzers, the digital 8-channel paper tape, and the analog strip-chart recorder. The flow chamber includes the compartment containing the water sample, the sensors, temperature compensators, and the system plumbing. The analyzers include those active or passive networks necessary for providing the linearized output voltages used as input to the recording phases. The analog and digital phases include components unique to each phase and are both electrically and mechanically independent of each other. Provisions for a fifth phase, transmission, are inherent in design.

The system shall be comprised of several independent (phases) compartments stacked one on the other and electrically cabled and mechanically connected together. All components within each modular phase shall be track mounted. However, it is not necessary to track mount the analog strip-chart recorder, but it shall be accessible for maintenance. Opening of all drawers shall not cause tipping of the system.[1]

The facility for supplying a water sample to the system at a rate between 5 and 20 gallons per minute and at a nominal pressure of 20 pounds per square inch will be provided by the system user.

The analyzers are to be active and are to be uniform in dimension, mechanically interchangeable, and symmetrically located on the front panel. Removal of any one analyzer shall not affect the operation of the rest of the system nor the calibration of any other parametric system unless otherwise noted. All active analyzers shall be accessible under power (for maintenance) without application of extension cabling.

Although independent (but not necessarily separate water sample) locations are to be provided for each sensor in direct contact with the water sample, facility for interchanging the location of each sensor without affecting the results of any parametric system shall be provided.

The solar radiation intensity sensor shall be located 50 feet from the analyzer component and shall be mounted on the roof of a shelter. A weather resistant, shielded cable shall carry the solar radiation intensity signal to the analyzer.

The contractor shall contact the project officer during the initial design stages at 50% and at 100% intervals during design and construction for authority to proceed with the system manufacture.

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[1] The modularity of the system permits selection of any parameter, or several identical parametric systems. Although a parameter, time is integral with the analog strip-chart recorder but will be provided as a module in the digital phase.

1.00 NOMENCLATURE

The following nomenclature will be employed throughout this specification:

1.01 "Analyzer" - the electronic components which are part of any parametric system and which transfer the signal output of a particular sensor to the recording device. The analyzer produces a voltage signal output which is a linear function of the measured water quality parameter. Each analyzer shall provide two full scale output signals: one volt positive, and one of either ten millivolts or 50 millivolts positive. Both outputs shall be referenced to ground potential.

1.02 "Code" - a row of punched holes in paper tape. A standard roll of punched paper tape can contain 120,000 codes.

1.03 "Counts" - The numerical value of the analog source signals punched in paper tape.

1.04 "Compartment" - the housing in the system for any specific phase. As an example, the analyzers will be located in an environmentally-sealed compartment that resists corrosion. (The electronic power supplies and reference supplies required by either the sensors or analyzers are also to be located in the analyzer compartment).

1.05 "Data word" - consists of any word in a record of data.

1.06 "End of line" - A punch in channel 8 which indicates an end of a record of data.

1.07 "Flow cell" - the device in which a primary sensor is located for measuring the sample influent. A flow cell is an integral part of the flow chamber and may consist of either a hole in a cover over one large container of sample under test, or it may consist of separate devices for each parametric system.

1.08 "Multiplexer" - The function which selects the different independent primary signals.

1.09 "Parameter" - any one of the physical and chemical quantities that the system will monitor.

1.10 "Parametric system" - a particular part of the total system for monitoring and recording a particular quality such as turbidity. The parametric system includes the primary sensor and the analyzer. (There is only one strip-chart recorder for the total system).

1.11 "Phase of system" - either the flow chamber and sensors, analyzers, analog strip-chart recorder, 8-channel paper tape recorder, or transmitter.

1.12 "Programmer" - the function which controls the operation of the digital phase.

1.13 "Probe", "Electrode" - the device for detecting a particular type of water quality parameter and generally in contact with the water. Examples include the sensors for measuring pH, conductivity, and dissolved oxygen.

1.14 "Record of data" - consists of the digital recording of time, test signal, pH, conductivity (low range, high range), dissolved chlorides (low range, high range), dissolved oxygen, oxidation reduction potential, solar radiation intensity, temperature, turbidity, and 'sample taker'.

1.15 "Sensor" - the device for detecting the various parameters and generating the primary electrical signals.

1.16 "System" - the entire water quality data acquisition system composed of integral parts employed for monitoring and recording the parameters of interest.

1.17 "Tab code" - the standard Friden Flexowriter code causing Flexowriter shift. It consists of holes in channels 2, 3, 4, 5 and 6 of the paper tape.

1.18 "Response time" - time required to reach 98% of a new steady state amplitude resulting in a step change of signal. The change in signal is due to temperature effects only, change in parameter amplitude at constant temperature, or a change in both temperature and parameter amplitude.

2.00 CONSTRUCTION

The system is to be comprised of four major phases: the flow chamber, the analyzers, the digital recorder, and analog recorder. (See Section 4.00).

2.01 Each phase of the system shall be environmentally sealed and shall operate satisfactorily in ambient environmental conditions consisting of 20°F to 120°F, at a relative humidity of 99%.

2.02 All locking bolts and screws shall be resistant to corrosion.

2.03 The compartments and mounting frameworks shall be constructed from a material that is resistant to corrosion from normal atmospheric conditions, raw river water, and saline waters.

2.04 Nominal overall outside dimensions of the system shall be 20 inches in depth, by 20 inches in width, by 75 inches in height.

2.05 The flow chamber shall be located on the bottom, the analyzer phase shall be located immediately above the flow chamber, the digital recording mechanism next, and the analog recording mechanism on top.

2.06 The active analyzer phase, the digital phase, and the flow chamber phase of the system shall be track mounted, and the active analyzers shall be readily accessible for servicing and replacement. The digital phase shall be readily accessible for paper tape replacement and maintenance.

2.07 Adequate end stops shall be provided on each phase to prevent unintentional removal from the system.

2.08 The compartments shall be uniform in finish and material with the possible exception of handles for carrying the system. The finish shall be baked gray enamel.

2.09 A four-caster dolly shall be provided to facilitate movement of the system. Leveling screws located on the bottom side of each corner of the dolly shall be provided.

2.10 Standard parts shall be employed in the construction with possible exception of those required for automatic temperature compensation and primary sensors.

2.11 Rivets shall not be employed for mounting replaceable components.

2.12 The flow chamber and sensors shall be readily accessible for cleaning and replacement.

2.13 Components requiring periodic servicing or replacement shall be identified.

2.14 Replacement assemblies and parts shall be interchangeable.

2.15 Modular design shall be employed in the construction of the primary and secondary assemblies.

2.16 Each phase of the system shall be removable and portable.

2.17 The analyzers shall be physically interchangeable with each other and the electrodes in the flow chamber shall also be physically interchangeable.

2.18 Circuits within the active analyzer shall be modular in design where feasible to facilitate maintenance and replacement. All active circuits in the analyzers, analog and digital recording phases, and power supply shall employ solid-state devices.

2.19 Calibration potentiometers to facilitate replacement of temperature compensators where employed and primary sensors shall be integral with each parametric system and located to facilitate field maintenance.

2.20 Active analyzers obtaining power from a common power supply are to be individually fused.

2.21 Visual indication of active analyzer failure shall be provided on the front of each active analyzer.

2.22 Two 5-foot extension cords for use with the active analyzers shall be provided to permit bench service on any given active analyzer.

2.23 The system shall operate from a nominal 115 Volt, 60-cycle-per-second source and shall maintain calibration and operate satisfactorily over a line voltage variation between 105 to 130 Volts AC at a line frequency of 60 cycles per second, ± 1 %.

2.24 The power cable supplying primary power to the system shall be three-wire and rubber-insulated. Standard wiring practice shall be followed with the ground line connected to the metal framework of the system.

2.25 The nominal 115 Volt alternating current input power cable (to the system) shall be isolated from signal-carrying conductors.

2.26 All major components that are supplied line voltage shall be fused and shall employ double-pole, single-throw toggle switches with clearly identified "on" and "off" positions.

2.27 All power terminals shall be insulated.

2.28 Electrical sockets, plugs, terminal board, and circuits shall not be exposed to water flow or splashing unless water sealed and shall be protected from high resistance shunting action due to condensation.

2.29 Visual indication of a complete failure in any phase of a parametric system, including power supplies, recorders, and sample flow, shall be provided.

2.30 The electrical connections between major components shall be by means of cables terminated in standard plugs and standard sockets for input and output.

2.31 Routine electrical test terminals shall be provided to facilitate maintenance.

2.32 There shall be an intermediate connecting point between the cable mechanically and electrically connected to the primary sensor assembly and its respective analyzer to facilitate field exchange of any given primary sensor assembly.

2.33 Individual terminals on terminal boards employed as intermediate connecting points shall be numbered and coded.

2.34 Color-code wiring shall be employed and identified on circuits and schematic diagrams.

2.35 Shielded cable shall be employed where stray currents may cause interference.

2.36 The intermediate connecting point (paragraph 2.32) shall be either a terminal board protected from water spillage employing non-corrosive terminals or a pressure plug and receptacle protected from water spillage and employing non-corrosive metallic contactors.

2.37 Fuses shall be protected from mechanical damage or short circuiting. (See Paragraph 2.20).

3.00 FLOW CHAMBER

The flow chamber contains the water sample under test, the plumbing, and sensors for measuring the parameters.

3.01 The flow chamber shall be designed for testing sea water and fresh water samples over a temperature range of 32°F to 110°F without causing interference or corrosive action.

3.02 The flow chamber, plumbing, and all components within the flow chamber shall be constructed from material that is resistant to corrosion.

3.03 The flow chamber shall be operated at or near atmospheric conditions (see page 2, paragraph 1).

3.04 All plumbing fittings shall be designed to prevent water leakage.

3.05 The flow chamber shall be designed so that a ±20% change in design point flow does not affect the magnitude of any parameter by more than ±1%.

3.06 The flow chamber shall be designed so that a sudden change from no flow to design point flow does not cause spillage.

3.07 The flow chamber shall not affect any specific parameter being monitored.

3.08 The flow chamber shall be designed to prevent electrical ground loops.

3.09 The flow chamber shall be designed so that any given parameter does not affect any other parameter.

3.10 The flow chamber shall be designed to permit visual inspection of all sides exposed to water with a minimum of dismantling.

3.11 The flow chamber shall be designed to minimize settling of turbid material.

3.12 The flow chamber shall be designed to facilitate periodic cleaning with a minimum of dismantling.

3.13 The flow chamber shall be designed to permit test sample acquisition from the most convenient location in the flow chamber without affecting the quality of that specific test sample; (i.e., test sample for determining dissolved oxygen with a Winkler process, etc.).

3.14 A minimum of 10 feet of standard hose extending from the rear of the flow chamber shall be provided for both influent and effluent.

3.15 Pressure hose for the influent shall be employed and supplied with standard female fittings, and the effluent hose shall be transparent and pliable. (See paragraph 3.14).

3.16 The inlet line shall be provided with a control valve for obtaining a water sample when selected conditions exist. The solenoid valve shall be located within 6 inches of the manifold end of the influent line and shall provide a sample flow to an exterior 2-gallon container through 1/2-inch plastic tubing. Control of the valve will be by action of the sample taker analyzer.

3.17 The cabling providing power to the sample taker solenoid valve shall be rubber insulated and shall be connected as a standard three-wire, male-to-female connector on the rear of the analyzer (or recorder) cubicle.

4.00 DATA RECORDING

The test signal and all parameters (pH, conductivity (low range, high range), dissolved chlorides (low range, high range), dissolved oxygen, oxidation reduction potential, temperature, turbidity, solar radiation intensity and sample taker) shall be recorded in either/both analog or/and digital form. The analog output shall be totally independent of the digital output, and the input signals to either phase shall be referenced to a common potential. Capability for recording time in digital form shall also be provided.

4.01 Analog: One multipoint, null-balance (potentiometric), strip-chart recorder shall be provided for recording signals from each parametric system and from the test signal.

4.02 The multipoint strip-chart recorder shall have the capability, with slight modification, to record 24 independent signals, although initially it will record only 12 parametric signals. (Time is inherent in chart movement).

4.03 The strip-chart recorder shall be provided with a left-hand zero.

4.04 The usable width of the scale portion of the chart shall be a nominal 10 inches, and the width of the paper shall be a nominal 12 inches.

4.05 The chart paper shall have a linear scale with unit amplitude markings at 0, 1, 2, and through and including 12. Each unit amplitude shall be subdivided into 20 divisions. Every unit and half-unit line shall be heavy shaded. Every-other line shall be medium shaded, and the remaining light shaded. Hence, the zero amplitude line shall be heavy shaded, the 0.15 line light shaded, the 0.10 line medium shaded, the 0.50 line heavy shaded.

4.06 Standard time markings for each hour at 1 inch per hour recorder speed shall be included on the center of the chart paper. Hourly time marking for chart speeds of 1/2 inch per hour and 2 inches per hour shall be located in the margin at minimum and maximum amplitudes, respectively.

4.07 A nominal 10 inch by 4 inch writing surface shall be located behind the exposed chart paper to facilitate marking of chart.

4.08 An internal lighting arrangement shall be provided in the recorder to facilitate chart reading.

4.09 The strip-chart recorder servoamplifier and power supply shall employ solid-state, active networks, and where feasible, shall employ modular design concepts to facilitate maintenance.

4.10 Full-scale deflection of the recorder shall correspond to the maximum value of any parameter, and zero deflection shall correspond to zero value of any parameter.

4.11 Full-scale deflection of the recorder shall occur for a maximum recording input signal of either 10 millivolts or 50 millivolts.

4.12 The recorder deflection for all parameters shall be a linear function of the parameter measured.

4.13 A test point (derived from the common power supply) shall be provided. Eighty percent pen travel for the test signal shall be considered normal, and a potentiometer shall be included to provide changes from 0% to 100% recorder deflection for the test signal.

4.14 The analog recorder shall operate from a nominal 115 Volts AC, 60 cps power source. (See 2.23).

4.15 The analog recorder amplifier and drive motors shall be fused for 115 Volt AC input power.

4.16 The time between consecutive printing of data points shall not be greater than 1 minute.

4.17 If the recording period between data words (points) is greater than 20 seconds, a manual point advance shall be provided.

4.18 Facility for interrupting the printing cycle shall be provided thereby permitting continuous observation of a given point.

4.19 Interruption of the printing cycle shall not interrupt movement of the chart paper.

4.20 Each recorded parametric point shall be identified, such as a unique color or numerical identification, or both.

4.21 The chart drive mechanism shall be provided with variable speeds including 1/2 inch, 1 inch, and 2 inches per hour. The chart speed shall be selected by a dial and identified.

4.22 The accuracy of the recorded data point shall be equal to or less than $\pm$0.25% of full-scale deflection.

4.23 The off-balance input impedance of the analog recorder shall not be less than 50,000 ohms.

4.24 The step response of the recorder (time to travel width of chart paper) shall not be greater than 6 seconds.

4.25 The feedback slide wire employed as the feedback potential source shall be covered to prevent accumulation of dust particles.

4.26 The weight of the analog recorder cubicle shall not be greater than a nominal 85 pounds.

4.27 The selector (multiplexer) switch shall be accessible for maintenance and shall be covered and sealed (rubber gasket) to prevent accumulation of dust particles.

4.28 Digital: Provisions for recording thirteen data words in standard 8-channel paper tape shall be integral with the digital phase. The data shall be recorded in binary coded decimal employing odd parity check.

4.29 The digital phase is to be comprised of the following:

1. Time.
2. Multiplex function.
3. Analog-to-digital conversion and translation function.

4. Programming function.
5. Punching function.
6. Power supply.

4.30 Time shall be recorded as a 6-digit parameter; 3 digits for days, 2 digits for hours, and 1 digit for tenths of hours. Days shall be separate from hours by a tab code. The most significant digit shall be punched first; the least significant digit last. The data word, time, shall include days, tab, hours, decimal point, and tenths of hours.

4.31 Time may be referenced to the line voltage frequency and it shall remain within ± 3 minutes over a 2-week period.

4.32 The maximum time shall correspond to a standard year of 365 days at the end of which time it shall automatically reset itself to day one, at zero hours.

4.33 A rotary stepping switch is acceptable for the multiplexing and programming function and, if employed, shall be enclosed in dust covers.

4.34 The digital phase shall operate over 1 of 3 ranges: 0-10 mv, 0-50 mv, or 0-1000 millivolts.

4.35 Full-scale inputs shall consist of one of either 0-10 mv, 0-50 mv, or 0-1000 mv, and shall be referenced to ground potential. The range of the input to the digital phase shall be selected by a three-position rotary switch. The switch shall be located internal to the digital phase and full-scale values shall be clearly identified.

4.36 The minimum input signal level from the primary system source will be zero volts, and this shall correspond to zero digital counts.

4.37 Potentiometric adjustments for zero digital output and full-scale digital output shall be provided and identified.

4.38 The input impedance of the digital phase shall not be less than 1 megohm.

4.39 Solid-state components employing voltage coincidence (ramp function) techniques shall be employed for converting analog signals to BCD.

4.40 The digital phase shall have the capability of converting and punching data at a minimum rate of five codes per second.

4.41 The analog signal voltage data shall be converted to four decimal digits. The most significant digit shall be punched first; the least significant digit last.

4.42 The decimal data punched in paper tape shall be recorded in digital counts. The maximum number of counts shall be 1200, and this shall correspond to the maximum analog voltage input signal.

4.43 The minimum number of counts shall be zero, and this shall correspond to the minimum signal level.

4.44 The error in converting the input analog DC voltage signal to binary coded decimal data in tape shall not be greater than $\pm$0.25%.

4.45 Translation circuit cards providing parallel-to-serial conversion shall be printed and employ solid-state devices and shall be readily removable to facilitate maintenance.

4.46 Modular BCD circuit cards shall employ solid-state components and shall be interchangeable.

4.47 A record of data shall consist of time and 12 parameters.

4.48 The sequence of punching data into 8-channel paper tape shall be time, parameters No. 1 through 12, and the end-of-line punch.

4.49 A pin board shall be provided between the signal input cable and multiplexing function to permit sequence exchange of data recording.

4.50 The data word, time, and each parameter except the last parameter in a record of data shall be followed by a standard Friden tab code. The tab code consists of a punch in channels 2, 3, 4, 5 and 6 of the 8-channel paper tape.

4.51 An end-of-line punch shall follow the last parameter to signify the completion of a record of data.

4.52 A rotary punch period control switch shall select punch periods, and the periods shall be clearly identified and marked as 0, 6, 12, 30, 60 and 120. The period shall be in minutes for the 6, 12, 30, 60 and 120 selections.

4.53 The zero position shall inactivate the punching capability of the digital phase.

4.54 A push button shall be provided for randomly obtaining a record of data and shall effect punching each time that the push button is compressed. Retaining the push button in the compressed position shall not cause continuous punching.

4.55 Compression of the push button for random punch shall activate the recording cycle within 2 seconds after compression.

4.56 The period control in Paragraph 4.52 shall control digital recording periods within $\pm$0.25% of the particular recording period.

4.57 Either a Friden, Tally or In-Vac 8-channel paper tape punch, or equivalent, shall be employed.

4.58 The digital punch shall be shock-mounted to prevent vibrational effects upon the cable connectors and electrical components.

4.59 The 8-channel paper tape recording shall be directly compatible with the IBM 047 tape-to-card converter.

4.60 A switch for manually selecting paper advance shall be provided and mounted on the front panel.

4.61 A removable container for collecting the paper chad shall be provided and shall have the capability of storing a week's chad (at a punching period of 60 minutes) without causing overflow or punch malfunction.

4.62 The diameter of the rewind wheel shall be the same diameter as the source wheel, and both shall have the capability of storing 1200 feet of standard 8-channel paper tape.

2.63 A single cable connector shall provide the signals, ground, and 115 Volt AC 60 cps power to the digital phase.

4.64 All power supplies required by the digital phase shall be self-contained and shall employ solid-state devices.

4.65 The 115 Volt AC 60 cps power shall be fused, and a double-pole, single-throw toggle switch internal to the digital phase shall be provided with the on-off positions clearly identified.

4.66 The panel layout of the digital phase shall include a window located on the upper half for visual display of time in days, hours and tenths of hours.

4.67 Reset and advance push buttons for days, hours and tenths of hours shall be located beneath the particular time component.

4.68 The period control switch shall be located on the upper right-hand corner of the front panel.

4.69 Lights for indicating power, parity and punch shall be located on the lower left of the panel layout.

4.70 Handles for pulling the digital phase from the compartment shall be located on each side of the panel.

4.71 An auxiliary 115 Volt, 60 cycle, 3-wire female socket shall be located on the rear panel and shall be electrically connected to the digital phase side of the primary power fuse.

4.72 The power output in Paragraph 4.71 shall be provided with a 0.1 ampere fuse.

4.73 Failure of any singular parametric system, including time, shall not prevent the digital phase from recording remaining valid data.

4.74 Functions obtaining power from a common power source are to be individually fused.

4.75 The digital phase shall maintain calibration and operate satisfactorily over a line voltage variation between 105 to 130 Volts AC at a line frequency of 60 cycles per second.

4.76 The weight of the digital phase shall not be greater than 85 pounds and shall be provided with handles on each side for manual carrying.

4.77 Overall outside dimensions of the compartment housing the digital phase shall be consistent with the outside dimensions of the recorder phase, analyzer phase, and flow chamber. The height of the digital phase shall not exceed 15 inches.

4.78 Telemetry: It is intended to eventually replace the analog and/or digital output phases with a transmitter without modification of the active analyzers. In these applications, parametric measurements at each water quality instrumentation system will be telemetered to a central facility.

4.79 The type of telemetry employed and the central station design (either an 8-channel paper tape data accumulation system with logging, or magnetic tape data accumulation with logging capabilities, or a digital computer with or without feedback capabilities) will be a function of the objectives of the monitoring program and the number of monitoring stations.

4.80 The transmitters will operate in the zero to 1000 millivolt range.

4.81 The input impedance of the transmitters shall not be less than one megohm.

4.82 Complete specifications for central data accumulation will be provided when the need arises.

5.00 SERVICE AND OPERATION MANUAL

Two copies of the manual for the data acquisition system containing information and maintenance procedure for each of four phases and each parametric system shall be provided.

5.01 A general description of each parametric system and detailed description of the components of each parametric system shall be included.

5.02 Discussion of each primary sensor shall be included as well as the electrical characteristics and chemical reactions where appropriate.

5.03 Installation instructions and details for installation of units and sub-units within each parametric system subject to replacement shall be included.

5.04 General and specific operation instructions shall be itemized.

5.05 A schedule of periodic maintenance of the components within each parametric system and the recorder shall be summarized.

5.06 A detailed and logical trouble-shooting procedure for the isolation and correction of malfunctions on a system and on a parametric basis shall be provided.

5.07 Parts lists, including location and identification of units and parts subjected to replacement, shall be included in the manual.

5.08 A cost breakdown of modular sub-units, such as an electrometer circuit assembly or an amplifier stage or reference supply or printed circuit boards, if employed, shall be included.

5.09 Replacement cost of each primary sensor and reference electrode and primary source of supply for those sensors shall be included.

5.10 A detailed calibration procedure and required peripheral instrumentation for calibration and specific calibration curves where applicable shall be included.

5.11 The schematic diagrams and wiring diagrams of all of the electronic and electrical circuits and the sample flow diagrams of the influent and effluent shall be included.

5.12 Exploded diagrams and pictures of assemblies and subassemblies to facilitate field maintenance shall be provided.

5.13 Replacement cost of active analyzers and potted circuit components shall be included.

5.14 Preferred maintenance procedures on all primary sensors including routine maintenance shall be included.

5.15 A source of supply for all components employed in the system, including part number to facilitate identification of that component shall be included.

5.16 An itemized summary of a recommended spare parts kit for the system shall be included.

6.00 CALIBRATION

All parametric systems are to be calibrated according to the following paragraphs unless otherwise specified:

6.01 Standards for calibrating the parametric systems pH, conductivity, dissolved chlorides, and oxidation reduction potential shall be provided by the user.

6.02 Five points over the full scale of each parametric system shall be checked; namely, zero or near zero, 25% of full scale, 50% of full scale, 75% of full scale, and full scale or near full scale, unless otherwise specified.

6.03 Each parametric system shall be checked at five different temperatures: 33°F, 50°F, 65°F, 85°F and 100°F, unless otherwise specified.

6.04 Calibration data obtained in 6.02 and 6.03 shall be included as part of the maintenance manual described in Paragraph 5.00.

6.05 Calibration circuitry shall be provided for each parametric system to facilitate calibration check points for each parametric system, exclusive of the primary sensor.

6.06 Readily accessible potentiometric adjustments for calibration shall be provided.

6.07 Exclusive of the primary sensors, each parametric system shall remain within $\pm$0.5% (of full scale) calibration over a four-week period without manual adjustment unless otherwise specified.

PART II - PARAMETRIC SYSTEMS

7.00 pH PARAMETRIC SYSTEM:

The pH parametric system shall include the glass electrode, the silver-silver chloride reference electrode, automatic temperature compensator, flow cell, calibration indicator, and active analyzer.

7.01 Operation and Performance: The pH parametric system shall have the capability for measuring an influent between zero and 12 pH units. The accuracy of the system shall be within $\pm$0.1 pH units between pH 2 and pH 12. The influent shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The active analyzer of the pH parametric system shall produce a temperature-compensated linear output as input to the analog and digital recording phases and transmitter.

7.02 The pH glass electrode shall have an internal impedance not greater than 25 megohms.

7.03 The reference electrode shall have the capability of supplying a head of KCl greater than the water pressure for a period of six weeks.

7.04 The automatic temperature compensator shall be mechanically independent of the glass electrode and reference electrode.

7.05 Potentiometers shall be included in the automatic temperature compensation circuitry to facilitate replacement of the temperature compensators.

7.06 To facilitate field maintenance, 15- to 24-inch leads connected directly to the glass electrode, reference electrode, and temperature compensators, shall terminate in a protected intermediate connecting point. (See Paragraph 2.36).

7.07 The sensor assembly leads shall be cabled and a coaxial cable shall be employed with the glass electrode. (See 7.06).

7.08 The pH parametric system shall be calibrated at room temperature employing Fisher Scientific buffer solutions of 10, 7 and 4 pH units, and this calibration shall agree within ±0.05 pH units of the buffer standards.

7.09 Calibration data for the pH parametric system employing the buffers indicated in 7.08 shall be obtained at 33°F, 65°F, and at 95°F and provided in the manual.

7.10 Calibration indicators and components shall be provided to facilitate the calibration of the pH parametric system exclusive of the primary sensors. (See 7.15).

7.11 The range of calibration potentiometer adjustment shall permit random replacement of the glass electrode and/or the reference electrode with electrodes of the same type as those integral with the system.

7.12 The response time of the pH parametric system shall not be greater than 5 minutes.

7.13 A pH of 12 shall produce full-scale deflection of the multipoint strip-chart recorder.

7.14 A pH of zero shall produce zero deflection of the multipoint strip-chart recorder.

7.15 The pH parametric system, including the recorded data point on the analog and digital recorders, shall be accurate within ±0.10 pH units over a 4-week period without intermediate maintenance or adjustments.

7.16 Temporary removal of the pH probe assembly shall not affect the calibration.

7.17 Exclusive of the glass and reference electrode, the pH parametric system shall remain within ±0.05 pH units calibration over a 4-week period without any manual adjustment.

7.18 The pH parametric system shall be automatically temperature compensated over a temperature range of 32°F to 110°F.

7.19 The pH parametric system shall be provided with a spare glass electrode and a spare reference electrode comparable to the electrodes employed in the system.

7.20 Electrical terminals at the electrodes and temperature compensators shall be sealed to prevent high resistance short circuiting of the electrodes due to water splashing or accidental spillage of electrolyte.

7.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000 ohm load.

7.22 Addition of the 25,000 ohm load in Paragraph 7.21 shall not affect the calibration more than $\pm$0.1%.

8.00 CONDUCTIVITY PARAMETRIC SYSTEM

The conductivity parametric system shall include the conductivity probe, the automatic temperature compensator, flow cell, calibration indicator, range indicators, and active analyzer.

8.01 Operation and Performance: The conductivity parametric system shall have the capability with slight modification for measuring an influent over two major ranges: (A) 0 to 6,000 micromhos; (B) 0 to 60,000 micromhos.

8.01-1 Capability for selecting ranges within each major range shall be provided according to the following paragraphs.

8.01-2 Manual range change:

8.01-2(a) Capability for manually selecting one of the ranges

A1 - (0 to 600)	A4 - (0 to 3600)
A2 - (0 to 1200)	A5 - (0 to 4800)
A3 - (0 to 2400)	A6 - (0 to 6000)

shall be provided by exchange of either a precalibrated and precompensated plug-in module or precalibrated and precompensated range spool without exchange of the conductivity cell and without physical exchange of the temperature compensator.

8.01-2(b) Capability for manually selecting one of the ranges

B1 - (0 to 6,000)	B4 - (0 to 36,000)
B2 - (0 to 12,000)	B5 - (0 to 48,000)
B3 - (0 to 24,000)	B6 - (0 to 60,000)

shall be provided by exchange of either a precalibrated and precompensated module or a precalibrated and precompensated range spool without exchange of the conductivity cell and without physical exchange of the temperature compensator.

8.01-2(c) Change of cell constant is acceptable in changing from major range A to major range B.

8.01-3 Automatic range change:

8.01-3(a) Capability for automatically changing the ranges within a specific major range from the minimum to the maximum ranges, i.e., from range A1 to range A6 (or from range B1 to range B6), and from range A6 to range A1 (or from range B6 to range B1), shall be provided. (Ranges defined in Paragraphs 8.01-2(a, b)). Automatic transfer from range 1 to range 6 is to occur at 90% full scale of range 1, and, automatic transfer from range 6 to range 1 is to occur at 80% of full scale of range 1.

8.01-3(b) A potentiometric adjustment or its equivalent shall be provided to permit changing the range transfer condition by ±10%. A toggle switch shall be provided to disconnect the automatic range change feature.

8.01-3(c) Indication of the range in use, such as the glowing of a lamp, shall be provided.

3.01-3(d) Each range shall be recorded as separate signals in all formats. When range 1, the low range, is operational, range 6, the higher range, shall record zero. Conversely, range 1 shall record zero when range 6 is operational.

8.01-3(e) Field exchange of major range A and major range B shall be effected manually.

8.01-4 The accuracy of the system shall be ±1% of full-scale deflection over the entire range. The influent will consist of unfiltered river water within a temperature range of 32°F to 110°F. The conductivity parametric system shall produce a temperature compensated linear output as input to the analog and digital recording phases and transmitter.

8.02 The effect of polarization at the conductivity cell shall be minimized. (See 8.03 and 8.15).

8.03 The conductivity cell shall not require manual cleaning more frequently than once each 4 weeks.

8.04 The automatic temperature compensators shall be mechanically independent of the conductivity probe.

8.05 Potentiometers shall be included in the automatic temperature compensation circuitry to facilitate replacement of the temperature compensators.

8.06 To facilitate field maintenance, 15- to 24-inch signal leads connected directly to the conductivity cell and temperature compensators shall terminate in an intermediate connecting point protected from electrolyte spillage and water splashing. (See 2.36).

8.07 To facilitate identity of each conductor, the leads to the conductivity cell shall be color coded. (See 8.06).

8.08 Each applicable range of the conductivity parametric system shall be calibrated and linearity determined employing potassium chloride standard solutions at or near 15%, 25%, 50%, 75%, and 100% of full scale.

8.09 Calibration data for the temperatures enumerated in Paragraph 6.03 employing the standard solutions indicated in 8.08 shall be obtained and provided with the conductivity parametric system as an integral part of the manual.

8.10 Calibration indicators and components shall be provided to facilitate field calibration of the conductivity parametric system exclusive of the conductivity cell. (See 8.15).

8.11 Replacement of the conductivity cell assembly with a similar conductivity cell assembly shall not affect the calibration by more than $\pm$1%.

8.12 The response time of the conductivity parametric system shall not be greater than 5 minutes.

8.13 Maximum conductivities for each range shall produce full-scale deflection of the multipoint strip-chart recorder.

8.14 A conductivity of zero shall produce zero deflection of the multipoint strip-chart recorder for each range.

8.15 The conductivity parametric system, including the recorded data point on the analog and digital recorders, shall be accurate within $\pm$1% for all ranges over a four-week period without intermediate maintenance or adjustments.

8.16 Temporary removal and replacement of the conductivity cell and temperature compensator shall not affect the calibration.

8.17 Exclusive of the conductivity probe, the conductivity parametric system shall remain within $\pm$0.5% of calibration over a four-week period without any manual adjustment.

8.18 The conductivity parametric system shall be automatically temperature compensated for a temperature range from 32°F to 110°F.

8.19 The conductivity parametric system shall be temperature compensated for the characteristics of potassium chloride and shall be referenced to 77°F.

8.20 Electrical terminals at the conductivity probe and temperature compensators shall be sealed to prevent high resistance short circuiting due to water splashing or accidental spillage of electrolyte.

8.21 A standard jack electrically connected to the primary direct current output of the analyzer shall be provided to permit addition of a 25,000 ohm resistive load.

8.22 The addition of the 25,000 ohm load in Paragraph 8.21 shall not affect the calibration more than $\pm$0.1%.

9.00 DISSOLVED CHLORIDES PARAMETRIC SYSTEM

The dissolved chlorides parametric system shall include the electrode, the reference electrode, the automatic temperature compensator, the flow cell, the calibration indicator and an active analyzer.

9.01 Operation and Performance: The dissolved chlorides parametric system shall have the capability for measuring dissolved chlorides in the influent over two ranges: (1) 0 to 240 mg/1 and (2) 100 to 2400 mg/1.

9.01-1 Capability for selecting range (1) or range (2) shall be provided according to the following paragraphs.

9.01-2 Manual range change capability for manually selecting either range (1) 0-240 mg/1 or range (2) 0-2400 mg/1 shall be provided by exchange of either a precalibrated and precompensated plug-in circuit module or selecting a precalibrated and precompensated circuit module with a toggle or rotary range selector switch without exchange of the primary sensor components.

9.01-3 Automatic range change:

9.01-3(a) Capability for automatically transferring from range (1) to range (2) and from range (2) to range (1) shall be provided. Automatic transfer from range (1) to range (2) shall occur at 220 mg/1 dissolved chlorides, and automatic transfer from range (2) to range (1) shall occur at 180 mg/1 dissolved chlorides.

9.01-3(b) A potentiometric adjustment or its equivalent shall be provided to permit changing the range transfer condition by $\pm$10%.

9.01-3(c) Indication of the range in use, such as the glowing of a lamp, shall be provided.

9.01-3(d) Each range shall be recorded as separate signals and in both analog and digital format. When range (1), the low range, is operational, range (2), the high range, shall record zero. Similarly, range (1) shall record zero when range (2) is operational.

9.01-4(a) The accuracy of the dissolved chlorides parametric system shall be ±5% of full scale within the following limits:

range (1): 20 to 240 mg/l
range (2): 180 to 2400 mg/l

9.01-4(b) The influent shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The dissolved chlorides parametric system shall produce a temperature compensated linear output and with zero offset as input to the analog and digital recording phases and transmitter.

9.02 The reference electrode shall be of the same type as the reference electrode employed in the pH parametric system.

9.03 The reference electrode shall have the capability of supplying a head of KCl greater than the water pressure for a period of six weeks.

9.04 The automatic temperature compensators shall be mechanically independent of the electrode and reference electrode to permit replacement.

9.05 Potentiometers shall be included in the automatic temperature compensation circuitry to facilitate replacement of temperature compensators.

9.06 To facilitate field maintenance, signal leads (15 to 24 inches) connected directly to the dissolved chlorides electrode, reference electrode, and temperature compensator, shall terminate in a protected intermediate connecting point. (See 2.36).

9.07 The dissolved chlorides primary sensor leads shall be cabled.

9.08 The dissolved chlorides parametric system shall be calibrated employing the following potassium chloride salt solutions at or near:

range (1): 20, 80, 160, 240 mg/l
range (2): 200, 800, 1600, 2400 mg/l

9.09 Calibration data for the temperatures enumerated in 6.03 employing the standard solutions indicated in 9.08 shall be obtained and provided with the discussion of the dissolved chlorides parametric system in the manual.

9.10 Calibration indicators and components shall be provided to facilitate the calibration of the dissolved chlorides parametric system exclusive of the primary electrode. (See 9.17).

9.11 The range of calibration potentiometer adjustment shall permit replacement of the dissolved chlorides electrode and/or the reference electrode with electrodes of the same type as those integral with the system.

9.12 The response time of the dissolved chlorides parametric system shall not be greater than 5 minutes.

9.13 Dissolved chloride concentrations of 240 mg/l for range (1) and 2400 mg/l for range (2) shall produce full-scale deflection of the multipoint strip-chart recorder.

9.14 A dissolved chlorides concentration of zero shall produce zero deflection of the multipoint strip-chart recorder.

9.15 The dissolved chlorides parametric system, including the recorded data point on the analog and digital recorder, shall be accurate within $\pm 5\%$ of full-scale deflection over the ranges specified in Paragraph 9.01.

9.16 Temporary removal of the dissolved chlorides sensor assembly shall not affect the calibration.

9.17 Exclusive of the primary sensor, the dissolved chlorides parametric system shall remain within ±0.5% of full-scale deflection over a four-week period without any manual adjustment. (See 9.10).

9.18 The dissolved chlorides parametric system shall be automatically temperature compensated for a temperature range of 32°F to 110°F.

9.19 The life expectancy of the dissolved chlorides electrode shall not be less than one year.

9.20 Electrical terminals at the electrode shall be sealed to prevent high resistance short-circuiting of the electrodes.

9.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000 ohm resistive load.

9.22 Addition of the 25,000 ohm load in Paragraph 9.21 shall not affect the calibration more than ±0.1%.

10.00 DISSOLVED OXYGEN PARAMETRIC SYSTEM

The dissolved oxygen parametric system shall include the electrode, automatic temperature compensator, flow cell, calibration indicator, and an active analyzer.

10.01 Operation and Performance: The dissolved oxygen parametric system shall have the capability for measuring dissolved oxygen in the river sample directly in milligrams per liter over the range of 0 to 24 milligrams per liter. The polarographic method for measuring dissolved oxygen shall be employed, and the accuracy of the system shall be within ±1% of full scale over the entire range of operation. The influent shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The active analyzer of the dissolved oxygen parametric system shall produce a temperature compensated linear output as input to the analog and digital recording phases and transmitter.

10.02 A passive dissolved oxygen electrode shall be employed.

10.03 The dissolved oxygen electrode shall have the capability of storing one month's requirement of electrolyte under normal operating conditions.

10.04 The automatic temperature compensator shall be mechanically independent of the dissolved oxygen electrode and shall be mounted to facilitate replacement.

10.05 Potentiometers shall be included in the automatic temperature compensator circuits to facilitate replacement of the temperature compensators.

10.06 To facilitate field maintenance, signal leads (15 to 24 inches) connected directly to the dissolved oxygen electrode and temperature compensators, shall terminate in a protected intermediate connecting point. (See 2.36).

10.07 Signal leads (Paragraph 10.06) shall be mechanically connected to a rigid framework of the dissolved oxygen probe assembly to prevent damage to electrodes.

10.08 The dissolved oxygen parametric system shall be calibrated in oxygen saturated distilled water at 33°F, 60°F, 85°F and 100°F, and verified with the Alsterberg modification of the Winkler method of dissolved oxygen determination. (See pp. 309, 312, The Eleventh Edition, Standard Methods for the Examination of Water and Waste Water).

10.09 Calibration data for the dissolved oxygen parametric system obtained in Paragraph 10.08 shall be included with the dissolved oxygen parametric system discussion in the manual.

10.10 Calibration indicators and components shall be provided to facilitate the calibration of the dissolved oxygen parametric system exclusive of the primary sensor.

10.11 Five premounted replacement membranes for the dissolved oxygen electrode shall be provided and the respective permeabilities shall not affect the calibration by more than ±4% for any random replacement.

10.12 The response time of the dissolved oxygen parametric system shall not be greater than 5 minutes.

10.13 A dissolved oxygen concentration of 24 milligrams per liter shall produce full-scale deflection of the multipoint strip-chart recorder.

10.14 A dissolved oxygen concentration of zero shall produce zero deflection of the recorder.

10.15 The dissolved oxygen parametric system, including the recorded data point on the analog and digital recorders, shall be accurate within ±1% of full scale over a 2-week period without intermediate maintenance or adjustment.

10.16 Temporary removal of the dissolved oxygen probe assembly shall not affect the calibration.

10.17 Exclusive of the dissolved oxygen electrode, the dissolved oxygen parametric system shall remain within ±0.10 milligrams per liter of the dissolved oxygen calibration over a four-week period without any manual adjustment.

10.18 The dissolved oxygen parametric system shall be (electronically) automatically temperature compensated over a temperature range of 32°F to 110°F.

10.19 The dissolved oxygen parametric system shall be provided with a spare dissolved oxygen electrode and a spare temperature compensator physically identical to those employed in the system. The electronic characteristics of the temperature compensators shall be within ±1% of each other.

10.20 Electrical terminals at the electrodes and compensator shall be sealed to prevent high resistance short circuiting of the electrode assembly and temperature compensator due to water or electrolyte spillage.

10.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000-ohm load.

10.22 Addition of the 25,000-ohm load in Paragraph 10.21 shall not affect the calibration by more than ±0.1%.

10.23 A ±20% change in system flow shall not affect the recorded dissolved oxygen more than ±1%.

10.24 The replacement membrane (Paragraph 10.11) shall be premounted in a rigid mechanical framework resistant to corrosion and shall be readily attached mechanically to the dissolved oxygen probe to facilitate field maintenance.

10.25 The mechanical device for connecting the replacement membrane (Paragraph 10.24) assembly to the dissolved oxygen probe shall be corrosion resistant.

10.26 The dissolved oxygen probe, including the membrane assembly, shall prevent leakage of the electrolyte and prevent water sample intrusion into the electrolyte.

10.27 The impedance between shorted leads of a "broken in" (after 24 hours) dissolved oxygen probe and a water sample having a conductivity of 300 micromhos shall not be less than 750,000 ohms.

11.00 OXIDATION REDUCTION POTENTIAL PARAMETRIC SYSTEM

The oxidation reduction potential (ORP) parametric system shall include the platinum inlay electrode, the reference electrode, the flow cell, calibration indicator, and an active analyzer.

11.01 Operation and Performance: The ORP parametric system shall have the capability for measuring oxidation reduction potentials in the influent over two ranges: (1) -600 millivolts through 0 to +600 millivolts direct current; and (2) 0 to +1200 millivolts.

11.01-1 Range: Each range shall be selected by a toggle switch with each position clearly identified.

11.01-2 Accuracy: The accuracy of the system shall be within $\pm$12 millivolts when the standard buffer solutions are measured as noted in Paragraph 11.08. The influent shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The active analyzer of the ORP parametric system shall produce a linear output as input to the analyzer and digital recording phases.

11.02 The reference electrode shall be of the same type as the reference electrode employed in the pH parametric system.

11.03 The reference electrode shall have the capability of supplying a head of KCl greater than the water pressure for a period of six weeks.

11.04 The ORP active analyzer shall be applicable to the measurement of pH with minimal modifications such as the exchange of the primary electrode assembly and insertion of the pH temperature compensating network circuitry.

11.05 Potentiometric adjustment for displacing the center zero by $\pm$110.0 millivolts shall be provided.

11.06 To facilitate field maintenance, signal leads (15 to 24 inches) connected directly to the ORP electrode assembly shall terminate in an intermediate connecting point.

11.07 The leads from the sensor assembly shall be cabled to facilitate handling.

11.08 The ORP parametric system shall be calibrated employing Fisher Scientific buffer solutions and quinhydrone accordingly:

(a) A solution of 0.5 grams of quinhydrone in 500 millliliters of a pH 4 buffer solution.

(b) A solution of 0.5 grams of quinhydrone in 500 millliliters of a pH 7 buffer solution.

11.09 Calibration data at 68°F and at 86°F for the solutions enumerated in Paragraph 11.08 shall be obtained and provided with the discussion of the ORP parametric system in the manual.

11.10 Calibration indicators and components shall be provided to facilitate the calibration of the ORP parametric system exclusive of the electrode assembly. (See Paragraph 11.17).

11.11 The range of calibration potentiometric adjustment shall permit replacement of the ORP electrode assembly with electrodes of the same type as those integral with the system.

11.12 The response time of the ORP parametric system shall not be greater than 5 minutes.

11.13 An ORP potential of +600 (+1200 on range 2) millivolts shall produce full-scale deflection of the multipoint strip-chart recorder.

11.14 An ORP potential of -600 (0 on range 2) millivolts shall produce zero deflection of the multipoint strip-chart recorder.

11.15 The ORP parametric system, including the recorded data point on the analog and digital recorders, shall be accurate within 12.0 millivolts over the range specified in Paragraph 11.01-1.

11.16 Temporary removal of the ORP sensor assembly shall not affect the calibration.

11.17 Exclusive of the primary ORP sensor assembly, the ORP parametric system shall remain within ± 6 millivolts over a 4-week period without any manual adjustment. (See Paragraph 11.10).

11.18 The ORP parametric system shall measure the potential of the influent over the temperature range of $32^{\circ}F$ to $110^{\circ}F$. (See 11.01).

11.19 The life expectancy of the platinum inlay electrode shall not be less than one year.

11.20 Electrical terminals at the electrode shall be sealed to prevent high resistance short circuiting of the electrodes.

11.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000 ohm resistive load.

11.22 Addition of the 25,000 ohm load in Paragraph 11.21 shall not affect the calibration more than $\pm 0.1\%$.

12.00 SOLAR RADIATION INTENSITY PARAMETRIC SYSTEM

The solar radiation intensity (SRI) parametric system shall include the radiation sensor, automatic temperature compensation, calibration indicator, mounting framework, and an active analyzer.

12.01 Operation and Performance: The SRI parametric system shall have the capability for measuring solar radiation incident to the sample source in calories per square centimeter per minute over the range of zero to 2.4 calories per square centimeter per minute. The accuracy of the system shall be within $\pm$1% over the entire range of operation. The sensor shall be exposed to atmospheric conditions over a temperature range of -20°F to 120°F. The analyzer of the SRI parametric system shall produce a temperature compensated linear output as input to the analog and digital recording phases and transmitter.

12.02 The SRI sensor shall produce at least 70% of full-scale transmittance between 0.315 microns and 4.20 microns.

12.03 The SRI sensor shall be mounted on a metallic platform no larger than 12" x 12" at a distance no less than 60 feet from the analyzer.

12.04 The automatic temperature compensator shall be mechanically independent of the SRI sensor and shall be mounted to facilitate replacement.

12.05 Potentiometers shall be included in the automatic temperature compensator circuits to facilitate replacement of the temperature compensators.

12.06 To facilitate field maintenance, signal leads (no longer than 24 inches) from the sensor shall be connected directly to a protected intermediate connecting point. (See 2.36).

12.07 Signal leads (Paragraph 12.06) shall be mechanically connected to a rigid framework of the sensor to prevent damage to the electrode.

12.08 The SRI parametric system shall be calibrated against a standard Eppley pyrheliometer.

12.09 Calibration data for the sensor obtained in Paragraph 12.08 shall be included in the instruction manual.

12.10 Calibration indicators and components shall be provided to facilitate the calibration of the SRI parametric system exclusive of the primary sensor.

12.11 Replacement of the primary sensor assembly shall not affect the calibration by more than $\pm 2\%$.

12.12 The response time of the SRI parametric system shall not be greater than 5 minutes.

12.13 A solar radiation intensity of 2.4 calories per square centimeter per minute shall produce full-scale deflection of the multipoint strip-chart recorder.

12.14 Zero solar radiation intensity shall produce zero deflection of the recorder.

12.15 The SRI parametric system, including the recorded data point on the analog and digital recorders, shall be accurate within $\pm 1\%$ of full-scale deflection over a four-week period without intermediate maintenance or adjustment.

12.16 Temporary disconnection of the primary sensor from the SRI parametric system shall not affect the calibration.

12.17 Exclusive of the primary sensor, the SRI parametric system shall remain within ± 0.01 calories per square centimeter per minute of the initial calibration over a 4-week period without any manual adjustment.

12.18 The SRI parametric system shall be automatically temperature compensated over a temperature range of $-20^{\circ}F$ to $120^{\circ}F$.

12.19 Sixty feet of weather resistant shielded cable shall be supplied with the SRI parametric system for carrying the primary sensor signal to the analyzer.

12.20 Electrical terminals at the sensor shall be designed to prevent high resistance short circuiting of the sensor assembly and temperature compensation.

12.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000-ohm load.

12.22 Addition of the 25,000-ohm load in Paragraph 12.21 shall not affect the calibration by more than $\pm$0.1%.

13.00 TEMPERATURE PARAMETRIC SYSTEM

The temperature parametric system shall include the temperature sensing element, compensation if required, calibration indicator, and an active analyzer.

13.01 Operation and Performance: The temperature parametric system shall have the capability for measuring an influent between $0^{\circ}F$ and $120^{\circ}F$. The accuracy of the system shall be $\pm 1^{\circ}F$ over the entire range. The temperature parametric system shall produce a linear output as input to the analog and digital recording phases and transmitter.

13.02 The temperature sensor shall be mounted in the flow chamber in direct contact with the sample, and may either occupy its unique location or share a location in the flow chamber with the dissolved oxygen sensor or conductivity cell.

13.03 Changing the location of the temperature sensor shall not affect any other parameter.

13.04 If an active temperature sensor is employed, its reference junction shall be compensated for ambient temperature changes.

13.05 If a passive temperature sensor is employed, potentiometers should be employed in the sensor circuitry to facilitate replacement of the temperature sensor.

13.06 To facilitate field maintenance, leads (no longer than 24 inches) connected directly to the sensor shall terminate in a protected intermediate connecting point. (See 2.36).

13.07 The casing in which the probe is mounted shall be resistant to corrosion.

13.08 The temperature parametric system shall be linear over the full range and shall be calibrated against a National Bureau of Standards laboratory thermometer, Type 15-040A.

13.09 Calibration data for the temperature parametric system shall be provided with the instruction manual.

13.10 Calibration indicators and components shall be provided to facilitate field calibration of the temperature parametric system, exclusive of the primary sensor.

13.11 Replacement of the temperature sensor with a similar sensor shall not affect the calibration by more than ±1%.

13.12 The response time of the temperature parametric system shall not be greater than 5 minutes.

13.13 A temperature of 120°F shall produce full-scale deflection of the multipoint strip-chart recorder.

13.14 A temperature of 0°F shall produce zero deflection of the multipoint strip-chart recorder.

13.15 The temperature parametric system, including the recorded data point in the analog and digital recorders shall remain within ±1.0°F over a 4-week period without intermediate maintenance or adjustment.

13.16 Temporary removal of the temperature sensor from the system shall not affect the calibration.

13.17 Exclusive of the temperature sensor, the temperature parametric system shall remain within ±0.5° of calibration over a 4-week period without any manual adjustment.

13.18 Potentiometers shall be included to facilitate replacement of the temperature sensor.

13.19 The life expectancy of the temperature sensor shall not be less than one year.

13.20 Electrical terminals at the temperature sensor shall be sealed to prevent high resistance short circuiting of the sensor.

13.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000-ohm load.

13.22 Addition of the 25,000-ohm load in Paragraph 13.21 shall not affect the calibration more than ±0.1%.

14.00 TURBIDITY PARAMETRIC SYSTEM

For measuring turbidity, the light absorption principle shall be employed. The turbidity parametric system shall include the light source and light sensitive cell, compensation for cell deterioration, automatic temperature compensation, automatic cleaning of light cell, calibration indicator, and active analyzer.

14.01 Operation and Performance: The turbidity parametric system shall have the capability for measuring a turbid influent between zero and 2400 Jackson candle units. The accuracy of the system shall be within ±25 Jcu in the range from 50 Jcu to 2400 Jcu. The influent shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The analyzer of the turbidimeter shall produce a temperature compensated linear output as input to the analog and digital recording phases and transmitter.

14.02 The turbidity sensor shall be submerged in the flow chamber.

14.03 Automatic cleansing of the turbidimeter cell windows shall be provided and the interior of the cell windows shall be free of fogging and condensate.

14.04 The automatic temperature compensation unique to the photo cell and light source assembly shall be integral with the sensor assembly.

14.05 Potentiometers shall be incorporated in the primary sensor circuitry to facilitate field exchange of either the sensor assembly or the unique electronic components of the assembly.

14.06 To facilitate field maintenance, leads (15 to 24 inches) connected directly to the turbidity primary sensor shall terminate in a protected intermediate connecting point. (See 2.36).

14.07 Electrical leads connected to the turbidity primary sensor assembly shall be mechanically fastened to the framework to facilitate handling.

14.08 The turbidimeter shall be calibrated employing equivalent river samples having turbidities of 50, 100, 240, 600, 1200, 1800, 2400, and verified with the Jackson candle unit.

14.09 Calibration data for the temperatures enumerated in Paragraph 6.03 employing the standards in Paragraph 14.08 shall be provided with the turbidity parametric system in the manual.

14.10 Calibration indicators and components shall be provided to facilitate the calibration of the turbidimeter.

14.11 The turbidity parametric system shall produce a continuous and linearized output as input to the multipoint strip-chart recorder.

14.12 The response time of the turbidimeter shall not be greater than 5 minutes.

14.13 A turbidity of 2400 Jackson candle units shall produce full-scale deflection of the multipoint strip-chart recorder.

14.14 A turbidity of zero shall produce zero deflection of the multipoint strip-chart recorder.

14.15 The turbidity parametric system, including the recorded data point in the analog and digital recorders shall be accurate within $\pm$25 Jcu over a 4-week period without intermediate maintenance or adjustment.

14.16 Temporary removal of the turbidity sensor shall not affect the calibration.

14.17 Exclusive of the turbidity primary sensor, the turbidimeter shall remain within $\pm$12 Jcu calibration over a 4-week period without any manual adjustment.

14.18 The turbidity parametric system shall be automatically temperature compensated over a temperature range of 32°F to 110°F.

14.19 The turbidity sensor assembly shall have a minimum life expectancy of 12 months.

14.20 Electrical terminals at the sensor assembly shall be sealed to prevent a high resistance short circuit of the sensor due to water splashing.

14.21 A standard jack electrically connected to the primary output of the analyzer shall be provided to permit addition of a 25,000-ohm load.

14.22 Addition of the 25,000-ohm load in Paragraph 12.21 shall not affect the calibration more than $\pm$0.1%.

15.00 SAMPLE TAKER PARAMETRIC SYSTEM

The sample taker parametric system shall include the cabling from the primary output of each parametric system, the active analyzers, timers, control solenoid valve, tubing, and plastic 3-gallon sample container.

15.01 Operation and Performance: The sample taker parametric system shall have the capability for accumulating one to three gallons of sample, for a selected acquisition setting, over the entire range of system operation for any of four parametric systems. The sample shall consist of unfiltered river water within a temperature range of 32°F to 110°F. The active analyzers of the sample taker parametric system shall operate directly or indirectly a 24 Volt solenoid control valve. The sample shall be accumulated at a nominal rate of one gallon per minute.

15.02 The automatic sample taker shall accumulate a sample for any one of the following conditions:

15.02-1 When one (or both) of two independent signals from independent parametric systems is (are) either:

15.02-1(a) Less than a pre-selected value;

15.02-1(b) More than a pre-selected value.

15.02-2 When one (or both) of two independent signals from independent parametric systems is (are) greater than a pre-selected value(s).

15.03 The pre-selected values in 15.02 shall be potentiometrically variable over the full range of operation.

15.04 The loading effect of the sample taker parametric system in either the inoperative, transient, or operative state shall not affect the calibration of any given parametric system by more than ±0.1%.

15.05 To facilitate field maintenance, the signal input leads to the active analyzers shall be cabled and terminate into either a standard plug or on a standard terminal board.

15.06 Operation of the sample taker parametric system shall provide continuous full-scale deflection of the strip-chart recorder and full scale indication in the digital phase (1200 counts).

15.07 The full-scale output signals of the sample taker parametric system shall be either 10 millivolts and 1000 millivolts direct current, or 50 millivolts and 1000 millivolts, direct current.

15.08 The signal in 15.07 shall be adjustable by ±10% of full scale.

15.09 Before operation, the sample taker parametric system shall provide continuous zero deflection of the strip-chart recorder and zero indication in the digital phase.

15.10 The conditions for accumulating a sample shall exist for a period of three minutes before a sample is taken.

15.11 The quantity of sample accumulated shall be adjustable over the range within ±5%. (See 15.01).

15.12 After sample acquisition, solenoid valve action shall be restricted until reset to prevent accumulating a second sample.

15.13 A toggle switch for inactivating the sample taker parametric system shall be provided and shall be located on the chassis of the active analyzers of the sample taker parametric system.

15.14 The sample taker parametric system shall be designed to permit its application either with or without the analog recorder, or, with or without the digital phase.

15.15 All functions in the sample taker parametric system, including active analyzers, shall be modular where feasible to facilitate field maintenance.

15.16 The sample taker shall control a 24 Volt solenoid valve located at the influent for sample acquisition. (See 3.16, 3.17 and 15.01).

15.17 The solenoid power cable shall be independently fused at its power source. (See 3.17).